Diagnostic and Prognostic Relevance of Magnetic Resonance Imaging and Electrophysiological Findings in Acute Spinal Ischemia

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Objective: Our purpose was to classify the rare entity of spontaneous spinal ischemia with clinical, magnetic resonance-tomographic, and electrophysiological parameters to determine criteria for outcome prediction. *Methods:* We analyzed the stroke registry database of the University Hospital Mannheim, Germany, from 2004 to 2010 for patients with a diagnosis of vascular spinal cord ischemia. *Results:* Ten patients were identified (mean age 65 years [range 50-83], 5 women). In 5 patients an etiology was found. Spinal diffusion-weighted magnetic resonance imaging revealed acute ischemia in 7 patients at initial imaging and this diagnosis was confirmed during the first week in the remaining 3 patients. Electrophysiological studies showed abnormal motor evoked potentials (MEPs) in 8 patients and abnormal somatosensory evoked potentials (SSEPs) in 7 patients. After rehabilitation, 5 patients had regained walking ability, whereas 5 patients stayed wheelchair bound. All patients with unfavorable outcome (American Spinal Injury Association (ASIA) Impairment score [AIS] score of ≤C) showed severe pyramidal tract lesions in MEPs during the first week. All patients with normal MEPs had an excellent outcome (AIS of E, $P < .05$). *Conclusions:* Diffusion-weighted imaging (DWI) is a useful tool to confirm acute spinal ischemia suspected in patients within the first days after symptom onset. Poor outcome was associated with severe electrophysiological abnormalities in MEPs and SSEPs. Normal MEPs were significantly predictive of an excellent prognosis. A multimodal diagnostic approach combining DWI and electrophysiological evaluation facilitates the prediction of the individual clinical outcome. **Key Words:** Spinal infarct—magnetic resonance imaging—diffusion-weighted imaging—motor evoked potentials—somatosensory evoked potentials—rehabilitation.

Introduction

Infarction of the spinal cord is a rare vascular pathology of the nervous system and represents 1%-2% of all vascular neurological pathologies.[1] This fact probably mirrors the nature of the vascular supply of the human spinal cord with its wide network of collaterals. Furthermore, the atherosclerotic disease seems to be much more common in the carotid arteries rather than the vertebrobasilar system probably related to their different anatomical characteristics. Due to the rarity of the disease, only a small case series of spinal cord ischemia have been published. Many of these case series

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recruited patients with diverse etiological factors such as aortic surgery or compressive myelopathies, or trauma.[2-4] Overall, clinical investigations so far evaluated either clinical, imaging, or electrophysiological parameters in patients with spinal cord infarction after surgery.

It has been suggested that diffusion-weighted magnetic resonance imaging (MRI) is a potentially useful tool to detect spinal cord infarction in the acute phase; still there are only few reports of representative series with diffusion-weighted imaging (DWI) in the spinal cord.[5,6] Electrophysiological studies using motor evoked potentials (MEPs) and somatosensory evoked potentials (SSEPs) have been used to characterize patients with spinal cord ischemia and cocaine abuse or as a monitoring technique during aortic surgery.[7-10]

We aimed to characterize patients with nonsurgical spontaneous spinal cord ischemia with their clinical, magnetic resonance-tomographic, and electrophysiological findings to determine the functional outcome.

Methods

We analyzed the stroke registry database of the University Hospital Mannheim, Germany, from 2004 to 2010 for patients with a diagnosis of vascular spinal cord ischemia. Ethics approval was given by the hospital's ethics committee (document ID 20138-3RM).

Final diagnosis was based on both clinical and imaging findings. Patients displayed symptoms of acute myelopathy (onset within minutes to a few hours) with a typical clinical pattern of bilateral symptoms. This clinical presentation—with central spinal symptoms in association with a spontaneous acute onset—were primarily interpreted as potential spinal ischemia. In view of the suspected diagnosis, spinal MRI was rapidly performed after clinical assessment, the conventional MRI findings guiding further interpretation. Patients suffering from compressive myelopathy, vascular malformation, acute myelitis related to demyelinating diseases, ischemia due to aortic surgery, central nervous system infection, as well as postinfectious or paraneoplastic syndromes were not included.

Standard Stroke Workup

All patients received a standard stroke workup including echocardiography, at least 24 hours' electrocardiographic monitoring, and extra- and intracranial Doppler–duplex sonography. Computed tomographic or magnetic resonance angiography was added to rule out a dissection of the vertebral arteries. All patients were screened for aortic pathologies as aortic dissection, aneurysm or atheroma, using transesophageal ultrasonography or computed tomography. Laboratory workup included standard blood values and a screening for thrombophilia (antithrombin deficiency, protein C and protein S deficiencies, factor V Leiden mutation and activated protein C resistance, prothrombin gene mutation, lupus anticoagulant and anticardiolipin antibodies, prothrombin time, activated partial thromboplastin time, international normalized ratio, and D-dimer). Serological screening included infectious causes (syphilis, Lyme borreliosis, herpes virus, and human immunodeficiency virus) and autoimmune diseases (antinuclear and antineutrophil cytoplasmic antibodies). Cerebrospinal fluid analysis included cell count and glucose and protein levels, Cerebrospinal fluid was also screened for oligoclonal bands, Lyme borreliosis, syphilis, or herpes virus infection if further evaluation was required.

MRI

Spinal MRI was performed in all patients within 24 hours after onset (Siemens MagnetomVison 1.5 T, Siemens Magnetom Sonata 1.5 T, or Siemens Magnetom Trio 3 T; Siemens, Erlangen, Germany). A standard protocol including DWI (in 7 of 10 patients), T2- and T1-weighted sagittal and transverse images, as well as T1-weighted images after contrast agent application of the cervical, thoracic, lumbar, and sacral segments of the spine was performed. A follow-up scan including DWI was added either when the clinical course required a control or when the initial scan had remained inconclusive.

Electrophysiology

SSEPs were determined with a Nihon Kohden Neuropack M1 MEB-9200 (Nihon Kohden, Tokyo, Japan). SSEPs were obtained on electrical stimulation of the median nerve at the wrist for the upper limb and at the tibial nerve for the lower limb. Latencies of the main peripheral, spinal, and cortical components were measured, and central conduction time was assessed consecutively.

MEPs to the 4 limbs were obtained with a Magstim 200 transcranial magnetic stimulator (The Magstim Company, Carmarthenshire, Wales, UK) The coil was placed tangentially to the scalp, with its center over the vertex. The patients were asked to contract slightly the target muscles (Musculus interosseus dorsalis I and Musculus tibialis anterior) at about 20% of the maximum voluntary effort to facilitate motor responses. Spinal roots were stimulated at C6-C7 and L4-L5 spaces. Central motor conduction time was measured as the difference between cortical and peripheral motor conduction times.

Evoked potential abnormalities were classified as normal or pathological by comparing latencies and amplitudes with normative data. Abnormalities on the MEPs and SSEPs were defined as (1) the absence of motor or sensory response, (2) absolute prolonged latencies and absolute lowered amplitudes, and (3) prolonged latencies or lowered amplitudes in comparison to the contralateral side.